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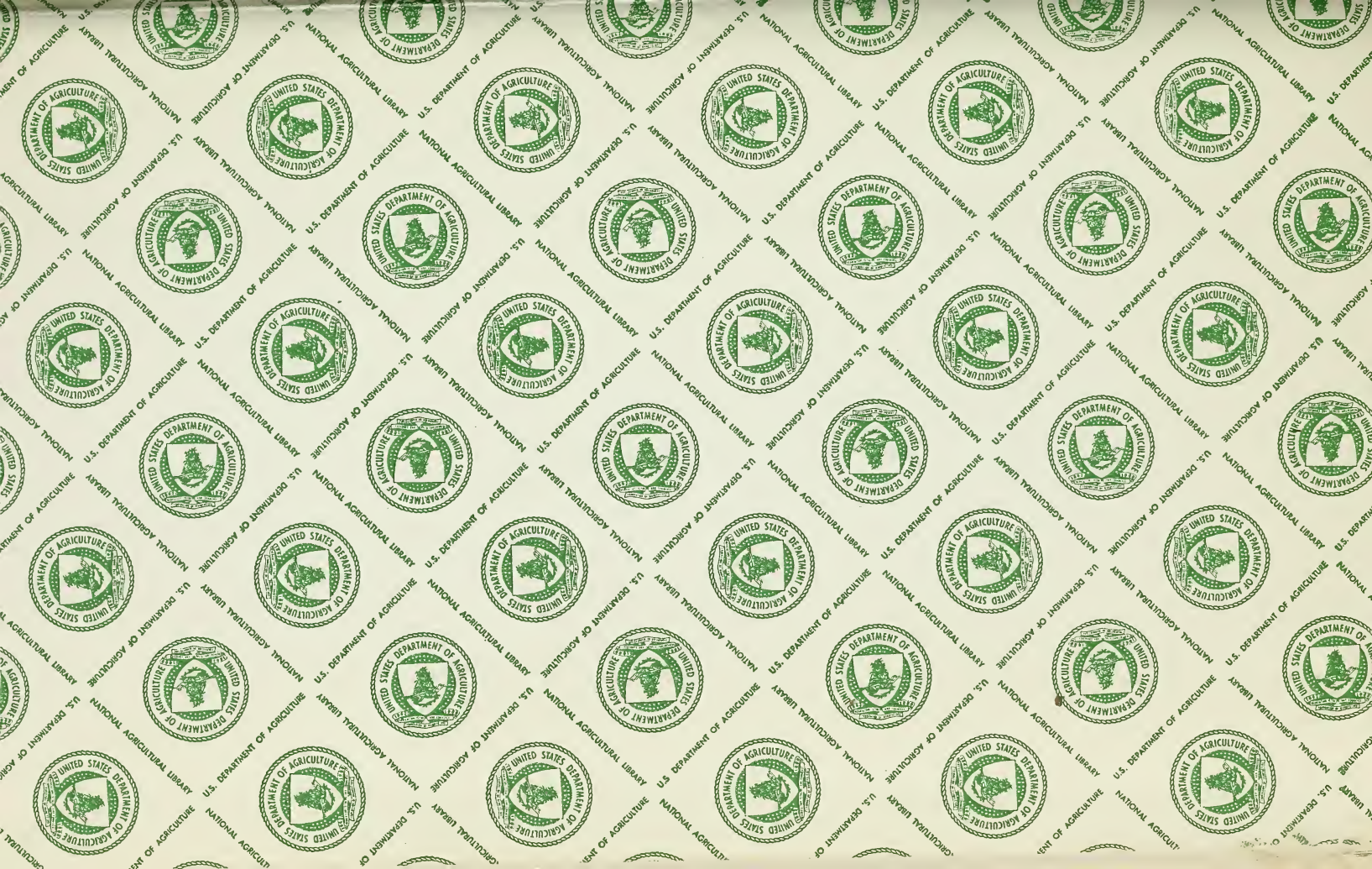
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PUERTO RICO EXPERIMENT STATION
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE PUERTO RICO EXPERIMENT STATION 1941

Issued December 1942

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
OFFICE OF EXPERIMENT STATIONS

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PUERTO RICO EXPERIMENT STATION

Administered by the Office of Experiment Stations
United States Department of Agriculture

JAMES T. JARDINE, *Chief, Office of Experiment Stations*

STATION STAFF

ATHERTON, LEE, *Director.*
W. K. BAILEY, *Horticulturist.*
C. L. HORN, *Associate Horticulturist.*
K. A. BARTLETT, *Entomologist.*
H. K. PLANK, *Associate Entomologist.*
R. H. MOORE, *Associate Plant Physiologist.*
A. G. KEVORKIAN, *Assistant Plant Pathologist and Physiologist.*
R. E. HARPER, *Assistant Plant Geneticist.*
J. K. ALVIS, *Assistant Agricultural Engineer.*
P. A. FOLCH, *Collaborating Agricultural Engineer.*[1]
E. HERNÁNDEZ MEDINA, *Collaborating Agronomist.*[1]
WILLIAM PENNOCK, *Collaborating Agronomist.*[1]
A. R. VILLAMIL, *Cooperating Agronomist.*[1]
C. ALEMAR, JR., *Collaborating Agronomist.*[1]
J. O. CARRERO, *Assistant Chemist.*
FRANCISCA E. ARANA, *Collaborating Chemist.*[1]
NEOMÍ G. ARRILLAGA, *Collaborating Chemist.*[1]
MERRIAM A. JONES, *Junior Chemist.*
HOWARD T. LOVE, *Junior Chemist.*
BEVERLY T. TAYLOR, *Scientific Aide.*
ARMANDO ARROYO, *Junior Scientific Aide.*
G. F. ANTON, *Collaborator.*
ASTOR GONZÁLEZ, *Cooperating Librarian.*[1]
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M. HOLLIS KANNENBERG, *Clerk.*
E. AVILÉS LOJO, *Cooperating Assistant Clerk.*[1]

[1] In cooperation with the Government of Puerto Rico.

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MAYAGUEZ, PUERTO RICO

Washington, D. C. December, 1942

REPORT OF THE PUERTO RICO EXPERIMENT STATION, 1941

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INTRODUCTION

In the following pages there is presented a record of the accomplishments of the Puerto Rico Experiment Station during the fiscal year 1940–1941. With this report we are radically changing the method of presentation. In view of war conditions it is necessary to reduce the volume of our annual report and confine it to a summarization of the major findings of the research conducted, leaving the details to be published elsewhere.

During the past year the station has continued its double function of serving as an outpost of the Department in the Tropics and of conducting research designed primarily for the benefit of Puerto Rican agriculture. In addition, the station has made available to interested Latin American countries technical information and the services of technical personnel.

During the course of the year the director, Atherton Lee, spent approximately 2 months in the Dominican Republic conducting an agricultural survey for the Brookings Institution, and about 1 month in Colombia on a similar assignment for the American-Colombian Corporation. Arthur G. Kevorkian, assistant plant pathologist and physiologist, was loaned to the Government of Ecuador for a period of about 2 months during the year, with the understanding that he would be available for transfer for another 12 months to organize an agricultural experiment station in that country.

Numerous visits were made to the station by scientists and agricultural technicians from Colombia, Ecuador, Haiti, and Guadeloupe,

who spent from a few days to several weeks visiting the station and discussing problems related to the agriculture of their native lands.

Through funds provided by the Work Projects Administration there has been practically completed a new laboratory wing, attached to the main building, which will provide considerable additional office and laboratory space. The building also contains modern rest rooms and provides additional storage space. The most modern equipment has been installed in all the chemical laboratories and throughout the building. The W. P. A. also provided funds for the construction of concrete roads in the main areas of the station grounds. These new roads add greatly to the beauty of the station grounds and reduce the continual expense entailed in the upkeep of gravel roads throughout the property.

PERSONNEL

A number of changes in personnel occurred during the year. William Pennock, agronomist, employed under funds appropriated by the Legislative of Puerto Rico, resigned October 31 to accept a position as field superintendent with Merck & Co., Inc., in Guatemala. Beverly T. Taylor, scientific aide, resigned October 31 to join the Soil Conservation Service in Georgia. Roy E. Harper was appointed assistant plant geneticist April 15. Carmelo Alemar, Jr., was appointed agronomist November 1, under the appropriation of the Legislature of Puerto Rico.

During the absence of the director from the station, Wallace K. Bailey served as acting director on various occasions, totaling about 2 months' time, and Kenneth A. Bartlett served in the same capacity for a period of about 1 month.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The station has maintained most cordial and cooperative relations with other agencies of the Federal and Insular Governments.

During the fiscal year the Legislature of Puerto Rico made available to the station $26,900 for studies relating to the agronomy and processing of vanilla, the propagation of spices and other tropical crops, the propagation and processing of essential-oil plants, and the extension and utilization of newly introduced bamboo. This program has resulted in considerable expansion of the work of the station, with resultant benefits to Puerto Rican agriculture.

The Insular Board of Vocational Education of the Department of Education provided several vocational students from the Mayaguez High School, on a part-time basis, for training in the laboratories of the station.

Complete cooperation was received from the Department of Agriculture and Commerce of Puerto Rico and from the College of Agriculture and Mechanic Arts and the Experiment Station of the University of Puerto Rico.

The Civilian Conservation Corps, administered by the Forest Service, has continued to provide men for a number of projects.

The National Youth Administration made available to the station a large number of youths for the dual purpose of furthering experimental projects and of training personnel in agricultural pursuits.

The Puerto Rico Reconstruction Administration, although curtailed during the year because of lack of funds, continued to extend complete cooperation and made available funds for the construction of an air-conditioned greenhouse for growth studies of cinchona seedlings.

The station provided laboratories, offices, and field areas for the Soil Conservation Service. Laboratory and office space was again made available to the Bureau of Entomology and Plant Quarantine of the Department and also to the Insular inspector of fertilizers and to the Insular plant quarantine inspector, collaborating with the Federal Bureau of Entomology and Plant Quarantine.

A gratifying spirit of cooperation has existed among all the agencies located at the station, and mutual benefits have accrued to the personnel from the associations which could be maintained in this way with other agencies of both the Federal and Insular Governments.

VANILLA

Agronomic Studies: Arthur G. Kevorkian and Ernesto Hernández Medina.

During the past year more evidence has accumulated to indicate that the incidence of root rot during the early stages of growth of the vanilla plant (*Vanilla fragrans* (Salisb.) Ames) can be minimized by planting in a substratum which provides good aeration and drainage. In a well-replicated experiment in which plants were grown in beds permitting side drainage and containing 1 foot of either gravel or Catalina clay over a 3-inch layer of coarse gravel and topped with a mulch of decaying plant material, only a small proportion of the plants in any treatment showed symptoms of root rot at the end of the experiment, 15 months after planting.

The dwarf bucare (*Erythrina berteroana* Urban) has been used extensively as a support on which to grow vanilla. In Puerto Rico this plant grows slowly and in most sections of the island is severely attacked by insects. The bucare also drops its leaves during the winter months, which is a disadvantage. As a consequence the station has been investigating the suitability of other trees as supports. Of these the cashew (*Anacardium occidentale* L.) appears to be particularly promising. The cashew grows rapidly and produces good shade and a framework of spreading branches well-adapted to the training of vanilla vines. An additional advantage of the cashew is the fact that it produces an edible nut, rich in oil, and an edible fruit, the juice of which has been reported to have a high vitamin C content.

It is the common practice in starting a vanillery to clear the land of all existing shade and burn or remove the trash. Suitable support trees are then planted, and after a period of from 1 to 2 years these produce sufficient shade for the initial planting of vanilla. This practice, of course, delays planting and leaves the land unproductive for a period of 1 to 2 years. In an experiment to show the effect of utilizing existing shade a parcel of land was prepared by clearing entirely one-half of the area and clearing only the underbrush from the remainder; then both portions were planted with support trees. When the bucare cuttings could provide proper

shade, vanilla cuttings were planted in each of the two portions. The results of the experiment indicate that, so far as the first year's growth is concerned, vanilla vines can be planted advantageously on land with existing shade with only a minimum amount of clearing, and that planting can be made immediately after land preparation. Root formation and vegetative growth were superior on those vines that were planted in the portion where existing shade was allowed to remain. Such vines had long, thin internodes and long, narrow, dark-green leaves, characteristic of healthy, normal plants. In comparison, the vines planted on cleared land had short, thick internodes; and the leaves were short, wide, cup-shaped, and abnormally yellow as a result of excessive exposure to the sun's rays intensified by the leaf shedding of the bucare supports during the dry season.

Vanilla plants do not commonly produce beans unless the flowers are artificially pollinated. It is the belief among vanilla growers that the development of an unusually heavy crop of beans weakens the plant to such an extent that only a small number of flowers, if any at all, develop for the following crop. The incidence of root rot also appears to be associated with fruiting. An experiment was conducted, in cooperation with a local vanilla grower at Villalba, to determine the effect of the extent of pollination on the vigor and health of the vines, with particular reference to the severity of root rot. The Puerto Rico Reconstruction Administration cooperated by making available the services of Rafael A. Suffront to assist in pollination.

A total of 250 apparently healthy plants was selected, and on 50 of these plants, taken at random, none of the flowers was pollinated; with other groups of 50 plants, each similarly selected, 25, 50, 75, and 100 percent of the flowers, respectively, were pollinated. Unfortunately, an unexpected disease condition made its appearance in the vanillery and became well established in some of the plants used in the experiment, which unquestionably distorted the final results to some extent. However, it is of value to record that the percentage of plants wilted or affected with root rot increased consistently with increased pollination. A much larger proportion of the plants of which 25 and 50 percent of the flowers had been pollinated was healthy following harvest than of those with larger percentages of pollination. Taking into consideration bean yield, length of beans, and the condition of plants following the final harvest, the 50-percent-pollination treatment gave by far the best results under the conditions of the experiment.

The development of a variety of vanilla that would be resistant to root rot and still produce an acceptable yield of high-quality beans is most desirable. In Puerto Rico there exists a species of vanilla, *Vanilla pompona* Schriede, that is extremely vigorous and highly resistant to root rot, but which produces inferior beans. Working in cooperation with Lewis Knudson of Cornell University, investigators have made reciprocal crosses between this resistant species and the commercially important species, *V. fragrans*, which yields the high-quality vanilla beans of commerce. From seeds supplied by the station, numerous hybrid vanilla seedlings are now growing on agar, and many more are expected to result from germinations being carried on at Cornell University; however, as young vanilla seedlings

grow slowly it will be some 10 to 15 years before sufficient plants of these seedlings are available for adequate testing.

During the year Arthur G. Kevorkian made a trip to Guadeloupe, funds for which were provided by the Puerto Rico Reconstruction Administration, to investigate the availability of vanilla cuttings for purchase and shipment to Puerto Rico. During this trip Dr. Kevorkian had the opportunity to make a brief survey of vanilla growing, and his observations are worth recording, as they substantiate the findings of our experimental work. The best vanilla vines found in Guadeloupe were growing on loose-textured, well-drained soils of neutral reaction. No attention was paid to support trees upon which vanilla is planted, nor was any given to uniform planting or spacing. Root rot was particularly prevalent in areas of heavy clay acid soil, and these plants resembled in all details plants similarly affected in Puerto Rico.

Processing: Arthur G. Kevorkian and Francisca E. Arana.

Studies on the processing of vanilla beans were continued during the year. An important factor in determining the quality of cured vanilla beans is the flexibility of the pods. Other things being equal, cured beans with a high percentage of moisture are more flexible than those of a low moisture content. Therefore, it is advantageous in the curing of vanilla to know to what weight a given lot of beans should be reduced in order to obtain a predetermined moisture content in the cured product. Curing experiments showed that the principal loss in weight was that of moisture and that other weight losses which might occur in the beans were of minor consequence. This loss can thus be calculated with considerable accuracy, provided that the moisture content of the fresh beans is known. Moisture determinations which can serve as a guide in this calculation were made during the past season. A weighted moisture content for different types of beans was found to be 81.2 percent for whole, green beans, 79.2 percent for whole, blossom-end-yellow beans, 79.0 percent for split, blossom-end-yellow beans, and 75.5 percent for split, chocolate-colored beans. The percentage of moisture in the beans tended to decrease as the degree of maturity increased.

In the processing of vanilla, after the beans have been subjected to the initial killing treatment they are generally sweated by a process of alternately heating in the sun and wrapping in blankets at night to hold the heat. This process is continued until the beans become flexible and soft to the touch. A comparison was made of the above sun-sweating procedure with that of continued sweating in an electric oven at 55° C. The time necessary for sweating, until the beans attained a desirable flexibility, was found to be greatly influenced by the sweating procedure used and to a less extent by the killing treatment. The maturity of the beans did not appear to affect the length of the period required for sweating. Sweating was always accomplished in a much shorter time in the electric oven than in the sun. The time required for the oven-sweating treatment varied from 3.8 to 7.5 days, whereas sun sweating took from 13.3 to 19.0 days.

In the course of processing experiments carried out this year, in which the curing process was started immediately upon receipt of the beans, the average total splitting at the end of curing was only 23.4 percent for blossom-end-yellow beans. Beans held for 6 to 7 days be-

fore the curing process was started showed a high degree of splitting, reaching 51 percent in the green beans and 85.3 percent in the blossom-end-yellow beans. These results emphasized the importance to the commercial grower of curing vanilla beans as soon after harvest as possible in order to avoid a high degree of splitting and a consequent lower price for the finished product.

A new method of processing vanilla beans by exposure to freezing temperatures as a killing procedure was further experimented with this year. Beans subjected to the freezing treatment were characterized by a fine and suave aroma, were improved in appearance, and had a uniform flexibility extending to the stem ends. Stem ends of beans killed by other procedures were usually dry and stiff unless a high content of moisture was left in the beans. The frozen beans were reddish brown in color, regardless of the degree of maturity, although this color usually characterizes only cured beans of well-advanced maturity.

Chemistry: Arnold K. Balls and Francisca E. Arana.

Again we were favored by having with us for a portion of the year Arnold K. Balls, head chemist in charge of the Enzyme Research Laboratory of the Bureau of Agricultural Chemistry and Engineering, who has cooperated in the work on the chemistry of vanilla curing.

The estimation of vanillin content has sometimes been used as an indication of the quality of both vanilla beans and vanilla extracts. The significance of such data may be questioned on the ground that beans from Mexico and Tahiti are both comparatively low in vanillin; yet, while the Mexican beans are more highly regarded commercially, the Tahitian beans are usually considered inferior in quality. Since vanillin content is not a criterion of flavoring value, it follows that other substances in the natural product contribute largely to the desired flavor.

It has been postulated that vanillin is only an intermediate product which undergoes changes that lead to compounds which may make an important contribution to the aromatic and flavoring properties of vanilla beans. The principles involved in the colorimetric method for determination of vanillin were utilized in the development of a photometric method for determining simultaneously not only vanillin but also other phenol compounds which appear to possess desirable flavoring properties. The method developed was finally tested by the addition of known quantities of vanillin to a representative vanilla extract, the added vanillin being measurable with satisfactory accuracy for comparative purposes.[1]

Beans of foreign origin purchased on the open market were found to follow the trend of market prices in relation to the greatest percentage of phenols present other than vanillin. The method for determining total phenols was also applied to extracts prepared from Puerto Rican beans subjected to different curing processes. While there was some variation in the phenol values obtained, the only outstanding process was that in which freezing was used as the killing agent, and this resulted in beans of an unusually high content

[1] Balls, A. K., and Arana, Francisca E. determination and significance of phenols in vanilla extract. Assoc. Off. Agr. Chem. Jour. 24 : 507–512, illus. 1941.

of total phenols, vanillin, and phenols other than vanillin. Although enough cured beans killed by the freezing method have not as yet been available to determine their comparative market value, the beans so treated were obviously of superior quality. As a consequence a public-service patent covering the process was applied for by Arnold K. Balls, Arthur G. Kevorkian, and Francisca E. Arana.

COFFEE

Variety Trials: In cooperation with Jaime Guiscafré Arrillaga and Luis A. Gómez, University of Puerto Rico Agricultural Experiment Station.

The Columnaris variety of *Coffea arabica* L., introduced by this station from Java, continued to outyield the West Indian variety commonly grown in Puerto Rico. During 1940, 1,581 pounds of marketable coffee were obtained from the Columnaris trees as compared with 687 pounds from the West Indian. Since 1934 the Columnaris variety has outyielded the West Indian by nearly 2 to 1.

In the study of fruiting habits, begun in 1937, a record was kept of the number of marketable coffee berries maturing from previously counted flowers on selected branches of an equal number of trees of the two varieties. The number of flowers formed annually on the Columnaris trees was practically the same in each of the past 3 years, whereas in the West Indian variety there was a distinct tendency for blossoming to fluctuate from year to year. Although the formation of a small number of flowers resulted in a large percentage of these flowers producing marketable berries in both varieties, the percentage maturing has not been large enough to prevent alternating heavy and light crops of berries in the West Indian variety.

ESSENTIAL OILS

Agronomic and Processing Studies: Antonio R. Villamil and Noemí G. Arrillaga.

Unsettled world conditions, which are making it difficult for the United States to obtain supplies of essential oils from southern Europe, northern Africa, and the East Indies, have emphasized the desirability of producing such oils in the Western Hemisphere, and have given the investigations of essential oils at this station added significance. Although these studies were undertaken to determine the possibilities of producing essential oils in Puerto Rico, the information obtained can serve to expedite their production in countries of the neighboring Western Hemisphere Tropics, thereby encouraging the development of sources of supply in areas readily accessible to the United States.

An experiment to determine the effect of sunlight intensity on the yield of oil from lemon grass (*Cymbopogon citratus* (DC.) Stapf.) showed that full sunlight was necessary for the maximum production of the grass and of oil and citral. When grown under full sunlight, nearly three times as much grass and more than three times as much oil and citral were produced as under one-third sunlight. There was a consistent increase in the proportion of oil in the grass as the intensity of sunlight to which the grass was exposed was

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increased. Although the citral content of the oil was higher for plants grown under some degree of shade, this was more than offset by the high yields of grass and oil obtained from plants grown in full sunlight.

An experiment to determine the best interval between harvests of lemon grass resulted in finding that a period of 21 weeks gave greater yields of grass, oil, and citral per acre per week of growth than shorter periods. There were consistent increases in the yield of grass and oil per acre per week as the length of interval between harvests increased from 12 to 21 weeks. The attendant saving in labor resulting from fewer harvests and distillations would make the 21–week interval more advantageous than any other tried.

Fertilizer experiments with lemon grass concluded during the year showed that little was gained by including phosphorus in a fertilizer mixture which contained nitrogen and potassium. Increasing the quantity of nitrogen per acre, however, showed that there were small but consistent increases in the yield of grass per acre with such increasing applications. This experiment was conducted on soils of high fertility, and it is probable that on soils of lower natural fertility similar applications of nitrogen would result in greater differences.

There would be many advantages if it were possible to store lemon grass for short or perhaps long periods after cutting. An initial experiment to determine the effect of drying in storage showed that no appreciable reduction in the quantity of oil extracted and no deterioration in the quality of the oil, as indicated by its citral content and specific gravity, resulted from storage in the shade for 7 days or storage in the sun for 5 days. Allowing the grass to dry reduced its bulk, with attendant savings in labor of handling for distillation.

Another economy that may be effected in the processing of lemon grass is to use the water remaining in the still after one immersion distillation to distill another charge of grass. Since under such an arrangement it is unnecessary after the initial distillation to prepare the still again for subsequent charges and the temperature of the water remains high, the next distillation may begin almost immediately, and considerable saving of time will result. The prompt re-use of the still water results also in a direct saving of fuel. An analysis of the oil distilled from a series of such charges showed that the yield and quality of the oil was not affected.

World conditions have largely shut off the supply of flower absolutes from southern France. Since coffee flowers are highly fragrant, and there is an abundance of coffee trees in Puerto Rico and other countries of the Western Hemisphere Tropics, different methods of extraction of the oil from coffee flowers were investigated. No measurable quantity of oil was obtained by steam distillation. The enflourage method, using purified lard as the nonvolatile solvent, gave a yield of 0.4 percent of a yellow aromatic oil, whereas extraction with petroleum ether gave a yield of 0.7 percent. When diluted to 1 percent in alcohol this essential oil gave a soft, agreeable perfume which had a faint note of cassie, mimosa, and jasmine and a faint, scarcely recognizable aroma of coffee. By its concentrated aroma it could be identified as an absolute. The yield of oil from

coffee blossoms compares favorably with that of the yield of other flower absolutes.

Chemical Studies: Noemí G. Arrillaga and Merriam A. Jones.

In some parts of the West Indies where there is a scarcity of fresh water, sea water is used in the distillation of bay oil. Experiments showed that the addition of salt to the still water increased not only the yield and quality but also the initial rate of entrainment of the oil. While these effects were noted with a number of salts studied, the use of potassium nitrate produced the highest yield of oil. With the use of sodium chloride in solutions of varying normalities it was shown that the chemical salted out and increased the yield of phenols in the oil. The use of soap resulted in an effect opposite to that produced by salt. From the studies made it was concluded that one of the effects of salt in the still water was to increase the heat efficiency of steam distillation by lowering the vapor pressure of the water. In incomplete distillation, such as that used in most small industrial plants, this resulted in an increase in yield efficiency also. However, in exhaustive distillation the increase of yield efficiency was not brought about by the vapor-pressure effect of salt but by the coordinate effect of plasmoptysis. The fact that most of the gains observed were in phenols makes it seem probable that salting out was also an important factor.

DRUG AND SPICE CROPS

Cinchona Production: Arthur G. Kevorkian.

During the past year the problem of producing cinchona in Puerto Rico has resolved itself largely into a matter of combating specific plant diseases. One virus disease, a stem canker, caused by fungi, and two root diseases have been definitely established as important factors limiting the development of vigorous trees. The canker disease has been found to be particularly prevalent among young plants. It has been found on *Cinchona pubescens* Vahl, referred to in previous reports as *C. succirubra* Pavon, *C. officinalis* L., *C. ledgeriana* Moens, and the hybrids *C. pubescens* × *officinalis*, and *C. officinalis* × *pubescens*. *C. pubescens*, which is said to be low in quinine content but is used as a stock plant in Java, seems to be particularly susceptible.

A root disease which is distinct from the canker disease was found prevalent in the permanent planting at Castañer. The symptoms of this disease were not readily detected. Trees that appeared to be making poor growth but were otherwise healthy wilted within a few days. All the leaves then dried out and remained attached to the tree for some time. Later these dried leaves dropped off, leaving bare, dead branches. When plants in this condition were dug up it was observed that all the main roots had rotted, leaving only short stubs. Adventitious roots had developed to prolong the life of most of the trees thus affected, but when these too were attacked the trees wilted and eventually died. The symptoms of this root disease have certain characteristics resembling those of the "gray root fungus" of Javanese *Cinchona* plantings caused by the *Graphium* or imperfect stage of a species of *Rosellinia*. In Java the root disease has been observed to be common in both permanent and nursery-bed plantings and particularly prevalent in clayey soils that are imperfectly

drained. The prevalence of this disease at Castañer may be due partially to the fact that this planting is on a poorly drained and poorly aerated clay soil. Although provision has been made for surface drainage, the soil is still highly retentive of moisture.

The *Cinchona* plantings of the station are in four localities, at altitudes ranging from approximately 1,000 to 3,000 feet and with diverse climatic conditions. At the end of the fiscal year the station had 314 *Cinchona* trees representing several species from 1 to 8 years of age established in permanent locations. Eighty of these trees are of the high-yielding species *C. ledgeriana*, and there are 285 trees of the same species from 6 inches to 3 feet in height growing in nursery beds.

Cinchona seeds lose their viability rapidly when stored for long periods under natural conditions of temperature and humidity. The storage of *C. ledgeriana* seeds for 12 months in an air-tight container with calcium chloride prolonged their viability, regardless of the storage temperature. Only 1 seed of 200 stored for an equal length of time under natural conditions germinated, whereas 30 percent of those stored over calcium chloride at room temperature and 33½ percent of those stored over calcium chloride in the refrigerator germinated.

In the *Cinchona* investigations at the station during the past 6 years the proportion of seed germinating has been small in relation to that planted. This was owing in part to maturity and viability of seed, but it was felt also that further experimentation of substrates should be conducted. Four substrates—sphagnum moss, peat moss, forest mulch, and sand—were tried. Seeds planted on peat moss were the first to germinate. Twenty-eight days from planting on peat moss more than twice as many seeds had germinated as on sphagnum moss, more than five times as many as on forest mulch, and three and five-tenths times as many as on sand. However, by the end of the eleventh week, sphagnum moss had produced 78.8 percent more seedlings than peat moss and sand and 118.5 percent more seedlings than forest mulch. The number of seeds germinating on sand and peat moss was 22.2 percent greater than on forest mulch. The differences between the number of seeds germinating on sphagnum moss and the number germinating on peat moss, on sand, and on forest mulch, respectively, were statistically significant. There were no statistically significant differences among peat moss, sand, and forest mulch.

Drug-plant Chemistry: Howard T. Love.

Analyses for alkaloid content of the bark of *Cinchona pubescens* trees in the Maricao planting were made for the second consecutive year. With one exception, the alkaloid content decreased during the year. There are three possible explanations for this decrease, all probably contributing factors. First, it is generally recognized among the cinchona planters of Java that after a certain stage of maturity, and especially after flowering, the alkaloid content of the bark decreases. All of the trees of the Maricao planting have flowered for at least 2 years. The second factor is that the studies conducted last year on alkaloid distribution necessitated the removal of a considerable area of bark from all sections of the tree trunk, which retarded the normal growth and development of the trees. The third

factor, suggested by other workers, is the possibility that some of the alkaloids from the surrounding areas of old bark were translocated to areas where bark was being regenerated.

Analysis of 1-year-old renewed bark revealed a total alkaloid content of from 1.51 to 3.25 percent in individual trees, or about one-half the amount of total alkaloids found in the surrounding old bark. This renewed bark was about one-half as thick as the surrounding old bark. Workers in the field have reported that renewed bark is always higher in alkaloid content than the old bark, but no reference was made as to the age of the renewed bark.

Analyses of some trees of *Cinchona pubescens* that were not normal in respect to growth because of disease or other unfavorable conditions, showed that these trees were generally low in alkaloid content. The bark was noticeably thinner than that of healthy trees of the same variety and age growing in the same locality. Apparently vigorous growth is necessary to produce maximum alkaloid content in cinchona bark, as well as to produce maximum yield of bark.

Digitalis is an important medicinal drug used in the treatment of heart diseases. The plant *Digitalis purpurea* L. can be grown in the northern sections of the United States, but in the past considerable quantities of the drug have been imported from Europe. While he was in Colombia during the past year, Atherton Lee, director of this station, noticed considerable quantities of digitalis plants growing wild, probably escapes from cultivation. In the thought that the South American digitalis might prove an additional source of this drug, samples were obtained and analyzed chemically. The leaves appeared to meet all physical requirements of the United States Pharmacopoeia.

The jimsonweed (*Datura stramonium* L.) is used in medicine in the form of ground leaves and of extracts prepared from the leaves. The leaves, and sometimes the whole plant, are used also to prepare the alkaloid hyoscyamine. This species, as well as several others of the genus *Datura*, grows well in Puerto Rico and is often found as a weed on cultivated land. A sample of *D. stramonium* leaves collected at random from plants growing in a cultivated field was dried in an oven at 80° C. The total alkaloid content was found to be 0.24 percent, which is slightly under United States Pharmacopoeia requirements. A more careful selection of mature leaves would probably have yielded a product meeting United States Pharmacopoeia specifications.

Spice Crops: Carmelo Alemar, Jr., and William Pennock.

In an experiment with the Jamaica variety of common ginger (*Zingiber officinale* Rosc.), mulching and large seed pieces produced the best rhizomes. The mulch treatments tried included the use of gray tar paper, straw, and no mulch; seed-piece sizes of 25 and of 50 grams each were used. There were no differences in yield among the mulched plats, but the yield of rhizomes obtained from the use of large seed pieces was 40.2 percent greater than the yield from the small seed pieces. On the paper-mulched plats growth of weeds and grasses was effectively checked, but the soil that was exposed was subject to severe erosion when rainfall was heavy. Soil erosion was heavy on the no-mulch plats, and control of weeds and grasses required constant attention. The use of straw mulch effectively checked

soil erosion. Considering soil erosion, weed and grass control, and yield, the straw treatment was the most satisfactory.

The station has continued its policy of collecting propagating material of different spice crops for establishment in permanent plantings. During the year permanent plantings were made of nutmeg (*Myristica fragrans* Houtt.), Ceylon cinnamon (*Cinnamomum zeylanicum* Nees), and tonka-beans (*Dipteryx odorata* (Aubl.) Willd.); and the plantings of Malaya cinnamon (*Cinnamomum burmani* Blume) and black pepper (*Piper nigrum* L.) have been extended. All these plantings have been made in the upper reaches of the Jagua Valley of the station in a forested area from which the underbrush had been cut out and the larger growth thinned in places. All of these crops appear to be well adapted to growing under conditions of partial shade, at least up to the present stage of growth.

BAMBOO

Propagation: Atherton Lee and Armando Arroyo.

The station has continued the policy of introducing promising new species and varieties of bamboo and of increasing propagating material from them for trial in Puerto Rico and elsewhere. During the year 12 plants of 3 new bamboos were received from the Agricultural Experiment Station, Paramaribo, Surinam (Netherlands Guiana), through the courtesy and cooperation of Gerald Stahel, the director. These plants were first grown in the plant-quarantine greenhouse of the Division of Plant Exploration and Introduction of the Bureau of Plant Industry at Glenn Dale, Md., for about 16 months and then forwarded to Mayaguez in November 1940. Although positive identification of these new bamboos has not yet been possible, it is believed that one of them is the highly valued Javanese Tali bamboo (*Gigantochloa apus* (Schult.) Kurz).

Both the permanent and the increase plantings of bamboo species previously introduced, and several new areas of nursery plantings of these and other species were developed during the year. In addition, 2,300 plants of 5 species were distributed to agencies of the Federal and Insular Governments and to private individuals for trial in different parts of the island. Among these plants were 1,050 plants of *Bambusa tulda* Roxb., P. I. No. 21002, which appears to be one of the best of the introduced species from the standpoint of adaptability, resistance to attack by the bamboo powder-post beetle, and suitability for timber.

Utilization: J. K. Alvis.

It is not uncommon for articles of bamboo sent by the station to the continental United States for exhibition to be returned in a cracked condition. This failure rarely occurs in the climate of Puerto Rico. It is thought to be the result of shrinkage caused by a greater degree of drying out of the bamboo than is common here. Consequently a study was initiated of the dimensional changes that accompany a change in moisture content in bamboo. A set of 20 test pieces was made up from several internodes taken from a culm of *Bambusa tuldoides* Munro that had been cut for some months and was apparently air-dry. Each sample was composed of two planed pieces of about equal thickness, with the inside wall faces glued

together. The results of these tests showed that the change in the volume of the bamboo used was slower than the change in weight up to 5.15 percent moisture content and that the reverse was true as more moisture was absorbed. The changes recorded in apparent specific gravity indicated a tendency for the volume to shrink faster than the weight as drying reduces the moisture content to 5 or 6 percent. The cracking of bamboo articles made in Puerto Rico when taken to the continental United States is therefore probably associated with this tendency of bamboo wood to change considerably in volume when exposed to atmospheres differing widely in relative humidity.

In the annual report for 1940 mention was made of the construction from *Bambusa tulda* of experimental split-bamboo fishing rods suitable for deep-sea fishing. The performance of these fishing rods has been so satisfactory that investigations have been furthered to explore the possibilities of utilizing some of the other introduced species in this manner to build up a small new industry for Puerto Rico.

By the use of machine tools and specially constructed forms it was possible for two men to prepare a rod in about 4 hours. This compared very favorably with the 2 weeks required to build the first rods, which were made entirely by hand.

Excellent rod butts of capá de sabana (*Petitia domingensis* Jacq.) and laminated royal palm (*Roystonea borinquena* Cook) were turned in the shop lathe. There are doubtless other native woods available that are suitable for this purpose.

Split-bamboo fishing rods are high-priced articles, and ready sale should be found for a limited number if priced fairly. Although the only bamboo now in Puerto Rico that is suitable for the construction of fishing rods is located on the station grounds, within 2 or 3 years sufficient culms should be available from other sources on the island to support a local industry.

VEGETABLE CROPS

Field Studies: Wallace K. Bailey.

A considerable amount of leaf lettuce is grown in Puerto Rico, but there are no commercial plantings of head lettuce, even though there is a fairly large demand and imports are therefore necessary. Four varieties of head lettuce were tested at two locations, one at sea level and one at an elevation of about 2,500 feet. In the lowland planting no satisfactory heads were produced; three or four plants of one variety, Imperial 44, developed soft heads.

At a higher elevation, however, an estimated 60 percent of the plants of this variety, Imperial 44, produced heads sufficiently large and compact to meet local requirements for head lettuce. The trimmed heads weighed from ¾ to 1¼ pounds each and were considered to be of unusually good quality. Unless future tests should reveal some limiting factor, it seems possible that head letture of acceptable market quality can be produced in Puerto Rico at all seasons of the year at elevations of 2,500 feet or higher.

In connection with the planting of head lettuce varieties, excellent seed reproduction was obtained from plants of Imperial 44. A count of the number of seeds in 35 representative seed heads, chosen at random from plants on which the flowers were subject to open pollination, revealed an average of 15.8 ± 0.47 seeds per seed head. This

suggested the possibility that Puerto Rico might be adapted to the production during the winter months of seed of some of the cool-season vegetable crops as well as seed of warm-season vegetable and agronomic crops.

That Puerto Rico is well adapted to the production of at least three warm-season vegetable and agronomic crops was definitely demonstrated during the past year. During the winter and spring the experiment station increased seed of two promising new strains of cantaloups for the department of horticulture of the University of Maryland and two promising new strains of bush lima beans for the Division of Fruit and Vegetable Crops and Diseases of the Bureau of Plant Industry.

At the same time a local sugar planter increased seed of a promising new variety of soybeans, the Seminole, for a farmer in North Carolina. Since this planting was a direct result of the work of the station, and is the first planting of soybeans of this type in Puerto Rico, pertinent information regarding the planting is briefly summarized here. Thirteen pounds of seed were planted on an area of approximately 0.62 acre and 375 pounds harvested. The planting was made on February 1, the first blossoms appeared March 2, and most of the seed was harvested from May 12 to 15. In this planting the rows were spaced 24 inches apart and the hills 12 inches apart in the row. Three seeds were planted per hill, and in many cases all of them germinated and produced plants. Some representative plants produced as many as 195 seeds each, with a total weight of more than 2 ounces.

SUGARCANE

Variety trials: Arthur G. Kevorkian and Ernesto Hernández Medina.

During recent years seed pieces of some of the most promising Mayaguez seedling varieties of sugarcane developed by the station have been distributed to interested growers for trial. Some growers have increased their planting material of these new varieties, and later, in cooperation with the station, have conducted well-replicated variety tests in which the varieties developed at the station have been tested against the standard variety for the particular district involved.

On medium-heavy clay soil, usually classified as type 25 Santa Isabel clay, the Mayaguez varieties M–275, M–314, M–317, M–326, M–340, M–341, and M–345 were tested against the district standard B. H. 10 (12). Seven of the Mayaguez varieties outyielded B. H. 10 (12) in cane tonnage and five in sugar per acre. The superiority ranged from a minimum of 6.36 to a maximum of 25.01 tons of cane per acre. However, only M–275 equaled B. H. 10 (12) in the quality of juice obtained. M–317 and M–314 had juice of the next highest quality. M–341 outyielded all the other varieties in sugar per acre, as well as in cane tonnage, producing 36.6 percent more cane and 27.1 percent more sugar per acre than B. H. 10 (12). The next best varieties in yield of sugar were M–275 and M–317, which produced 23.1 and 18.9 percent more sugar per acre, respectively, than B. H. 10 (12). M–326, which yielded 32.5 percent more cane than B. H. 10 (12), produced only 6.8 percent more sugar because of the poor quality of its juice. B. H. 10 (12) produced 8.51 percent less cane

but 5.67 percent more sugar per acre than M–345, and 10.2 percent more cane and 13.9 percent more sugar than M–314.

Another experiment with the same varieties but set out on compact heavy clay soil classified as type 120 Aguirre clay, was harvested during the year. All but two of the Mayaguez varieties yielded more cane and more sugar per acre than the district standard B. H. 10 (12). On this soil type these Mayaguez varieties surpassed B. H. 10 (12) in cane tonnage from a minimum of 2.82 tons to a maximum of 15.32 tons per acre and in sugar yield from a minimum of 1.29 tons to a maximum of 2.20 tons per acre. Statistical analysis showed that the difference in cane production between each of four Mayaguez varieties (M–340, M–341, M–317, and M–326) and B. H. 10 (12) was highly significant. The differences in cane yield among these four Mayaguez varieties were not statistically significant, but all were superior to M–275 by high significance. M-340 yielded 30.4 percent more cane per acre than B. H. 10 (12) and 37.3 percent more sugar; whereas M–341, which yielded only 27.8 percent more cane, produced 41.8 percent more sugar. M–317 yielded 24.6 percent more cane and 37.6 percent more sugar than B. H. 10 (12), as compared with 23.4 percent more cane and 30.4 percent more sugar for M–326. M–275, which produced only 5.6 percent more cane than B. H. 10 (12), yielded 24.5 percent more sugar. B. H. 10 (12) produced 10.4 percent more cane and 0.3 percent more sugar per acre than M–314, as compared with 7.8 percent more cane and 3.5 percent more sugar than M–345.

During the year 48,349 seed pieces of 18 Mayaguez varieties were distributed to sugarcane growers in 17 localities.

INSECTICIDAL PLANTS

Physiology and Agronomy of Rotenone Crops: Rufus H. Moore and Merriam A. Jones.

Scattered observations on several rotenone-producing species of plants have indicated strongly that rotenoid cells were formed in greatest numbers during flushes of growth and that starch-containing cells were formed when growth was slow. These observations were verified under controlled conditions in a greenhouse experiment in which a clone of a St. Croix variety of tubaroot jewelvine (*Derris elliptica* (Roxb.) Benth.) was used as the experimental species. Two sets of plants were involved in this test. One set, herein referred to as the low-carbohydrate series, was maintained under conditions favoring growth; the other, the high-carbohydrate series, was maintained under conditions unfavorable to growth.

The plants in both series underwent a more or less rhythmic cycle of growth flushes alternating with periods when the growth rate was relatively slow. Growth flushes of the high-carbohydrate plants were relatively weak, and when they began to appear they were repressed by removing all nitrogen from the nutrient solution. The entire experiment was continued for a period of 2 years and 8 months to allow these slow-growing plants time to develop enough roots for chemical analysis.

At harvest the fresh weight of the roots and tops of each plant was recorded. The average fresh weight of the tops of the low-

carbohydrate plants was 16.2 times that of the tops of the high-carbohydrate plants. The corresponding figure for the fresh roots was 4.0. The top/root ratio for the low-carbohydrate plants was 7.45 in contrast to the corresponding ratio for the high-carbohydrate plants of 1.85.

It is of practical significance that the average weight of air-dry roots of the low-carbohydrate plants was 4.9 times as great as that of the high-carbohydrate plants. The low-carbohydrate plants, then, greatly surpassed the high-carbohydrate plants in the production of new tissues.

On an air-dry basis and depending on diameter, the roots of the low-carbohydrate plants were from 1.8 to 7.3 times as high in rotenone as roots of high-carbohydrate plants. Weighted means showed that the former had 3.9 times the percentage of rotenone found in the latter; in total extractives there was a similar trend.

Examination showed that the nutritional level of the plants in the two series was reflected in root structure. High-carbohydrate plants were hard to cut, and even those root tissues formed during the weak growth flushes had few rotenoid cells. Low-carbohydrate plants cut easily and had alternating bands of rotenoid and starch-containing root tissue. Roots of low-carbohydrate plants had thinner bark and thinner-walled cells generally than did roots of high-carbohydrate plants. The relative wall thickness of the fiber cells was especially obvious. In the low-carbohydrate plants these walls were so thin that the cell cavities were the conspicuous parts of the cells. In the high-carbohydrate plants the walls of the fiber cells were so thick that the cell cavities were scarcely discernible.

The results of this experiment bear directly upon field practices that might be used advantageously by growers of derris. They show that derris may be expected to develop its highest commercial value when growing vigorously. Expressed in terms of field management this means that the formation of rotenone and total extractives would be favored by the application of ample water and fertilizer.

Among the plants of cube (*Lonchocarpus nicou* (Aubl.) DC.) that have been included in clonal studies is a plant of which the air-dry roots were found to contain 14 percent of rotenone. In a test to determine the value of completely covering bud shields of this clone with paraffined-muslin tape as compared with the common practice of partial coverage, it was found that complete coverage gave a 47.9-percent higher incidence of graft unions on the average than partial coverage. When coverage was complete, old bud shields without wood and young shields with wood were about equally successful, and both were superior to young shields without wood. Partial coverage was most successful with old bud shields, less successful with young bud shields without wood, and was least satisfactory with young shields with wood.

In general, variations in the diameter of stock plants had little effect on the success of bud transfers, but an appreciably higher percentage of young buds developed graft unions with small stocks than with medium and large.

The budding trials demonstrated that, in addition to the young bud shields ordinarily used in grafting, buds taken from both old and immature parts of the scion stem can be utilized to increase the

clonal material of *Lonchocarpus nicou;* that stems of all sizes in this species can be successfully used as stocks; that the most economical and time-saving procedure would be to graft young and immature bud shields with wood on small stems, completely covering the grafts with raffia or paraffined tape; and that *L. chrysophyllus* Kleinh. can be used as a stock for propagating *L. nicou* by bud grafting.

PLANT INTRODUCTIONS

Field Studies: Claud L. Horn.

During the year propagating material of 211 species of plants was received. Of these, 33 species were palms, mostly ornamentals. A small Central American palm, *Neanthe bella* Cook, showed promise of becoming of commercial importance. It is expected that this species can be successfully propagated in Puerto Rico to develop a reliable source of seed that could be exported to the mainland where the palm is used as a house plant.

A promising lawngrass, Transvaal dogtoothgrass (*Cynodon transvaalensis* Buntt-Davy), was obtained from the Division of Plant Exploration and Introduction of the Bureau of Plant Industry and tried during the year. This grass is quite similar to its widely distributed close relative, Bermuda grass (*C. dactylon* (L.) Pers.). The leaf blades of Transvaal dogtoothgrass are almost $\frac{1}{16}$ of an inch wide and $\frac{1}{2}$ to $\frac{3}{4}$ of an inch long, while the leaves of Bermuda grass are approximately $\frac{3}{32}$ of an inch wide and $1\frac{1}{2}$ to 3 inches long. Under similar environmental conditions it appears that this new grass will grow equally as well as the coarser Bermuda grass. Both prefer light, well-drained soil but grow well with little rainfall and withstand drought.

A new breadfruit variety of superior quality was obtained from the Department of Agriculture, Barbados, British West Indies. In comparing this variety with the white-fleshed sort, such as that commonly planted in Puerto Rico, that department indicated that the yellow fruits not only have a more desirable color but also a better flavor.

The leaf sheaths of Manila hemp, or abacá banana (*Musa textilis* Nee), a relative of the common banana, yield a fiber that is of value in rope making, of which the large supply for the United States heretofore came mainly from the Philippine Islands. For many years a small planting has grown well on a steep hillside of clay soil at the station. During the past year this small planting was extended so that more is now available for planting in Puerto Rico or other parts of tropical America.

The existence of a truly white bougainvillea has frequently been mentioned. The occurrence of such a variety in Brazil was known, and, through the courtesy of the Instituto Agronômico do Estado de São Paulo at Campinas, several cuttings of this variety were received. The bracts are absolutely white, with the exception of a small amount of light green in the midrib and in the large veins. The white bracts have a beautiful, fine-granular translucency which gives an appearance of snow. At Mayaguez this variety has flowered in profusion from late fall to early spring and sporadically throughout the remainder of the year.

The showy combretum (*Combretum grandiflorum* G. Don) has become very popular in Puerto Rico. This plant is a climbing shrub, the leaves of which are a shiny green except near the end of the branches, where they assume varying shades of red and do not develop to normal leaf size. The vermilion, nonfragrant flowers are borne closely packed in one-sided racemes. Several thousand plants have been propagated from the original two plants received in Mayaguez in 1933, and these plants have given excellent results in many places throughout the island. As a cut flower this species makes most attractive floral arrangements, the colors of which are most desired during the Thanksgiving-Christmas holiday season. There is the possibility that this tropical species may be successfully grown commercially in Puerto Rico for cut-flower shipments to New York.

Specimen plants of the large guanacaste earpodtree (*Enterolobium cyclocarpum* (Jacq.) Griseb.) were first received at the station in 1916. One of the first specimen plants has reached a diameter of 60 inches at breast height in 24 years. It is perhaps the most admired specimen in the plant-introduction gardens. The earpodtree is a legume which, because of its form and not-too-dense crown, should be well suited as a pasture tree. It has been observed that many pasture grasses grow better in the shade of some leguminous trees than they do in the open.

An interesting study of polyembryony in mango (*Mangifera indica* L.) seed was completed during the year. In some mango varieties the egg cell has never been observed to divide. Such varieties can, however, produce viable embryos from the innermost cells of the nucellus. Embryos thus derived are from mother tissue only, and plants resulting from such embryos have the characters of the mother plant. This means of reproduction is termed apogamy, and within one seed several apogamic embryos often develop. In some varieties the fertilized egg cell does develop into an embryo that is usually larger than the accompanying apogamic embryos. In polyembryonic mango seeds one embryo can be derived from the fertilized egg cell; all the accompanying embryos must be apogamically derived.

Studies were made of 7,880 mango seedlings of 20 varieties to determine the number that were polyembryonic, the number that were monoembryonic and unbranched underground, and also the number that, from the soil surface, appeared to be polyembryonic but in reality were monoembryonic and branched below the soil surface. Only one variety, Giraffe, was more than 50-percent polyembryonic, while only four varieties were more than 25-percent polyembryonic. This study would seem to make the few records of high polyembryony in mango to be the exception rather than the rule.

A practice of propagating and distributing to other parts of the island for further trial those plant species that have been found to be of value was continued. In addition, large numbers of plants were propagated for other Government agencies such as defense projects, the Agricultural Extension Service, the Forest Service, and low-cost housing developments sponsored by the United States Housing Authority. Plants totaling 208,000 were thus distributed during the year. Propagating material of several plant species was also supplied to the governments of Barbados and Trinidad, B. W. I., British Guiana, Colombia, and the Dominican Republic.

ENTOMOLOGY

Biological Control Activities: Kenneth A. Bartlett.

During the year 2,591 adult flies of the São Paulo strain of the Amazon fly (*Metagonistylum minense* Towns.) were liberated throughout the island to parasitize the sugarcane borer (*Diatraea saccharalis* (F.)). Both the Amazon and São Paulo strains were recovered in collections of sugarcane borers made throughout the year at Santa Isabel, Cabo Rojo, Mayaguez, and Guayanilla to determine the presence and effectiveness of introduced parasites. In positive fields the parasitization varied from 0.5 to 6.1 percent. The highest parasitization noted was 46 percent, found in collections of sugarcane borers infesting corn at Mayaguez.

Through the cooperation of the South American Parasite Laboratory of the Bureau of Entomology and Plant Quarantine, three shipments of *Paratheresia diatraeae* (Bréthes), a fly parasite of *Diatraea saccharalis*, were sent to Puerto Rico. The parasites were collected at Itaquaquecetuba, in the State of São Paulo, Brazil, by H. L. Parker and N. Townsend. Puparia were collected from corn, packed in moist sphagnum and shipped by air express to Puerto Rico. From a total of 3,101 puparia received there emerged 894 flies.

From the 2,719 borers of *Diatraea saccharalis* inoculated from February to June with larvae of *Paratheresia diatraeae* there emerged 1,003 adult flies, a percentage of 36.9. Liberations of *P. diatraeae* throughout the island totaled 981 flies.

Through arrangements effected by C. P. Clausen, in charge of the Division of Foreign Parasite Introduction, Bureau of Entomology and Plant Quarantine, a shipment of 24 mated females of the São Paulo strain of *Metagonistylum minense* was made to Houma, La., and a similar shipment of 14 to Guadeloupe. A shipment of 20 mated females of *Paratheresia diatraeae* was made to Cuba.

The coccinellid, *Coelophora inaequalis* (F.), introduced from Hawaii in 1938 as a predator of aphids, was found during the year to be well established at various points. Although it was originally hoped this predator might be of value in the control of the yellow sugarcane aphid (*Sipha flava* Forbes) it has proved to be a general aphid feeder.

The hymenopterous parasite *Pseudaphycus utilis* Timb., introduced from Hawaii in 1939 to aid in the control of the palm mealybug (*Pseudococcus nipae* (Mask.)), is now well established in many areas and is spreading rapidly. Two collections of *Pseudococcus nipae* made at San German in July 1940 showed a parasitization of 86 and 81 percent, respectively, by *Pseudaphycus utilis*. Collections at Lajas and Boqueron, some 20 kilometers from the original liberation points, showed a parasitization of 49 to 52 percent, respectively.

The introduced coccinellid predators, particularly *Egius platycephalus* Muls., *Chilocorus cacti* L., *Pentilia castanea* Muls., *Cladis nitidula* F., and *Curinus* sp., continue to be highly effective in the control of the bamboo scales *Asterolecanium bambusae* (Bdv.) and *A. miliaris* (Bdv.). The predators have proved particularly effective in the control of *A. bambusae;* evidence of their beneficial work is readily observed by the large number of clean culms found in contrast

to the heavy infestations prevailing prior to the introduction of these predators.

In addition to effecting control of bamboo scales, the predators have been observed also feeding on other scales, particularly *Chionaspis citri* Comst. and *Lepidosaphes beckii* (Newm.) on citrus and on miscellaneous scales, including the white peach scale (*Pseudaulacaspis pentagona* (Targ.)) on papaya and the black thread scale (*Ischnaspis longirostris* (Sign.)) on coconut. *Chilocorus cacti* has been observed in large numbers feeding on the green scale (*Coccus viridis* (Green)) at Mayaguez.

Through the cooperation of the Division of Foreign Parasite Introduction of the Bureau of Entomology and Plant Quarantine, a shipment of dipterous parasites that attack various species of pentatomids was received in October from P. A. Berry, Santiago, Chile. The shipment contained 38 puparia and 55 adult flies. The material arrived in fair condition, 31 flies of *Ectophasiopsis arcuata* (Bigot)[2] and 9 flies of *Cylindromyia porteri* (Bréthes)[2] being alive on arrival. Two flies of a third species were dead on arrival and could not be identified because of their poor condition. The *C. porteri* flies were weak and in poor condition, and it is believed only two females were present; both of these died within 24 hours after arrival without ovipositing. The *E. arcuata* flies were extremely active on arrival, and mating took place in many instances while they were being released from the shipping container. When placed with various species of pentatomids and coreids, the females showed an active interest, and oviposition was readily obtained. However, the parasites failed to develop in any of the host species tried, and dissections of both dead and living host material did not reveal the presence of any developing parasite larvae.

Dasyscapus parvipennis Gahan, a parasite of thrips, particularly the red-banded thrips (*Selenothrips rubrocinctus* (Giard)), was introduced into Trinidad in 1936 from the Gold Coast, Africa, through the cooperation of the Director of Agriculture for Trinidad and Tobago and the Imperial College of Tropical Agriculture, Trinidad. Some of the stock was later furnished to this station, and the rearing of this parasite species in the laboratory was continued until May 1939, during which time large liberations were made frequently in many sections of the island. Observations made at Cabo Rojo and Mayaguez during the past year showed that a large number of the *S. rubrocinctus* infesting tropical almond (*Terminalia catappa* L.) and mango (*Mangifera indica*) were parasitized by the introduced parasite. At both points the parasites were abundant and readily found. Near a liberation point in Yauco, small numbers of *Dasyscapus* were found parasitizing *S. rubrocinctus* on tropical almonds. Near another liberation point at San Juan two parasite pupae were found in about 1 hour's search. It can be stated with certainty that *D. parvipennis* is established in a number of sections of the island where liberations were made 2 to 3 years ago.

General Investigations: HAROLD K. PLANK.

In the rearing of the bamboo powder-post beetle (*Dinoderus minutus* (F.)), it was found that the beetles were stimulated to activity

[2] Determined by D. G. Hall, Bureau of Entomology and Plant Quarantine.

and left their tunnels as the sunlight faded after midafternoon. A cone cage was constructed which permitted easy capture of the beetles during this period of activity, and thus ample material was provided for experiments in progress.

During the year six species of bamboo were tested as to their susceptibility to the powder-post beetle. Standard test pieces in the form of rings three-quarters of an inch in thickness were taken from culms known to be in their first year of growth and were selected from each of three internodes of the culm, the bottom, middle, and top.

The results, analyzed statistically, showed that the variation in beetle attacks among species, clumps, and positions was highly significant. The average susceptibility as compared with *Bambusa vulgaris* Schrad. for the various species studied was as follows: *B. tulda*, P. I. No. 21002, 2.18 percent; *B. tulda*, P. I. No. 74413, 2.35 percent; *B. tuldoides* 9.24 percent; *Dendrocalamus giganteus* Munro, 6.67 percent; and *B. polymorpha* Munro, 16.76 percent.

Considering all species and varieties as a whole, there were more than 7 times as many beetle attacks on the pieces from the bottom and middle than on the pieces from the top. The difference in susceptibility between the bottom and middle internodes was not significant.

As in previous experiments, the presence of starch in the wood was tested for by placing a drop of $\frac{1}{40}$-normal solution of iodine and potassium iodide on the cut edge of the testing ring. The intensity of the resulting blue color as judged visually was taken as an indication of the relative abundance of starch in the wood. The rings showing the strongest reaction were those from the species that were most attacked by the beetle. In all the species the test rings from the bottom and middle internodes showed the strongest reaction from the iodine test.

Two scale insects, the mining scale (*Howardia biclavis* (Comst.)) and the hemispherical scale (*Saissetia hemisphaerica* (Targ.)), were found causing damage to the station *Cinchona* plantings at Castañer, Many of the permanent trees, particularly those making poor growth, were severely attacked. Thorough spraying with a light oil emulsion at about 1-percent strength resulted in good control.

Extensive vine girdling and leaf damage was observed in vanilla plantings near Mayaguez during the year. Examinations showed that a small snail, *Subulina octona* Brug,[3] and the large slug *Veronicalla kraussii* Ferussac,[3] were principally involved. The snails had dirty-white, spiral, conical shells about $\frac{3}{4}$ of an inch long and about $\frac{1}{4}$ of an inch wide at the mouth. The slugs, variously marked with dull yellow and black, were about 2 inches long by about $\frac{3}{4}$ of an inch wide near the middle. Both species were found in large numbers in the trash used as mulch around the base of the vines. Cage tests demonstrated that most of the damage was caused by the slugs.

Injury by the snails was apparently confined to minor skeletonizing of the leaves. In confinement, the snails were seen to feed very little and then only where characteristic damage by the slugs had already been started.

The slugs, on the other hand, not only ate out large holes from the centers of the leaves, like the snail *Thelidomus lima* Fér, reported in 1938, but also consumed large patches from the edges, like the

[3] Determined by Paul Bartsch, curator of mollusks, U. S. National Museum.

larvae of the tiger moth *Ecpantheria icasia* (Cramer), reported in 1937. Besides sometimes killing the tips of the new growth, the slugs also frequently fed on the roots that held the plant to the support tree and skeletonized the leaves in such a way that nothing was left of them but a few fibers which were formerly the veins. Perhaps the most destructive and important injury noted was the feeding on the outer tissues of the stem, in many places for a distance of over 6 to 8 inches, which resulted in the girdling and death of the plant at these points.

Beginning in August and lasting well into the winter, *Aphis rumicis* L., commonly known as the bean aphid, was noted severely attacking the orange-glowvine (*Senecio confusus* Britten), a promising new ornamental extensively planted in this part of the island. The blue-green to yellow-green adults were abundant on the twigs and underside of curled leaves on the new growth, where their feeding caused a stunting of the new tips, an abundance of sooty mold over the leaves, and a reduction in blooming.

During the early and middle part of June a relatively large, red aphid, *Macrosiphum sonchi* (L.), was found moderately infesting this same ornamental.

Aphis rumicis is known to attack a wide range of hosts and has been recorded on a few plants in Puerto Rico.[4] *Macrosiphum sonchi* is a common and well-distributed species infesting a large number of the plants of the family Compositae, but has not been previously reported from the island. A search of available literature[5] did not reveal a record of either species attacking *Senecio confusus*.

During the past few years a method has been developed for controlling the dry-wood or powder-post termite *Kalotermes* (*Cryptotermes*) *brevis* (Walker) by injecting orthodichlorobenzene or a saturated solution of paradichlorobenzene in kerosene into the colonies. With the idea of making the wood resistant to future attack, these solutions were later diluted with an equal part of a solution containing, by weight, 5 percent of commercial pentachlorophenol in kerosene or a light Diesel fuel oil. These materials used over a period of 3 years have almost eliminated the termites from a badly infested station residence, and their use for 1 year has so effectively reduced the infestation in another badly infested residence that few adults have been observed inside the house during the year, as compared with hundreds during former years.

In order to prevent the introduction of any insects or plant diseases not now present in the island, plant introductions made by the station have been brought in under authority of a permit issued by the Department of Agriculture and Commerce of Puerto Rico, and, in accordance with Insular Plant Quarantine Law No. 35, such plants have been held in quarantine for a period of not less than 6 months. During this period the plants have been kept under constant observation by representatives of the Insular and Federal plant-quarantine services, working through the local Insular plant-quarantine inspector and the plant pathologist and entomologist of the station.

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[4] WOLCOTT, GEORGE N., "INSECTAE BORINQUENSES": A REVISED ANNOTATED CHECK LIST OF THE INSECTS OF PUERTO RICO. With a Host-Plant Index by José I. Otero. Puerto Rico Univ. Jour. Agr. 20: 1–627, illus. 1936.

[5] Including PATCH, EDITH M. FOOD-PLANT CATALOGUE OF THE APHIDS OF THE WORLD, INCLUDING THE PHYLLOXERIDAE. Maine Agr. Expt. Sta. Bul. 393, pp. 35–431. 1938.

During the fiscal year ended June 30, 1941, the plant-quarantine house was utilized most of the time to full capacity in accommodating a total of 552 plants of 180 species introduced under 9 Insular permits. Of these, 139 plants of 35 species received during the previous fiscal year and 83 plants of 11 species received during the present year were released from quarantine. Of the remaining plants, most were held because of insect infestation or plant diseases or because their quarantine period had not expired.

CHEMISTRY

Laboratory Studies: José O. Carrero.

Chemical analyses of the residue obtained from steam distillation of fresh lemon grass and of lemon grass immersed in a 2-normal solution of common salt were made during the year to determine their value as a feed for dairy cattle. The results showed the grass to be decidedly deficient in protein and low in total sugars.

An orientation experiment in which coffee seedlings were grown in nutrient solutions was carried out in cooperation with Jaime Guiscafré Arrillaga, coffee specialist, and Luis A. Gómez, assistant coffee specialist, of the Agricultural Experiment Station of the University of Puerto Rico, to determine the best solutions to utilize for deficiency studies.

The two best of Shive's three-salt nutrient solutions were modified and used as primary solutions. The primary solutions were varied by omitting different elements and varying the acidity. Each treatment was replicated five times, each replicate consisting of five 2-inch plants suspended in a 1-liter, tall-form beaker. Aeration was provided by slowly forcing cleaned air through the nutrient solution in each beaker.

This primary experiment with nutrient solutions indicated that copper was one of the minor elements important to the proper growth of coffee seedlings. However, until the concentration of copper in the solutions had been lowered to between 0.02 and 0.04 part per million there was a strong tendency toward chlorosis and poor development of roots and tops.

AGRICULTURAL ENGINEERING

Miscellaneous Studies: J. K. Alvis.

The construction of an efficient and cheap solar water heater was perfected during the year. Observations made indicated that to supply warm bath water for a family of four, a 40-gallon standard range boiler connected to an absorber coil made up of 160 feet of ¾-inch black pipe will ordinarily be sufficient. The storage tank should be mounted considerably higher than the absorber unit and must be completely insulated with a dry organic material such as sawdust or sugarcane bagasse. The heating coil can be economically laid in a space 40 feet long, in two parallel circuits. The pipe in the coil should be laid so that the connection to the supply line that extends down from the lower plug in the tank is at the lowest point in the coil, and so that from this point the pipes forming the absorber lead continuously upward to the return line which connects to the upper tank plug. A low place or sag in the absorber coil

interferes with water circulation and will result in poor heating. A grade of 1 inch in 15 feet of pipe length proved satisfactory. The supply and return lines should be made of larger pipe than the absorbing coil. On bright days when the usual temperature was about 75° F., water temperatures of 140° have been obtained with these solar heaters. Even on cloudy days the water was sufficiently warm to eliminate chill and make the water comfortable to the touch.

PUBLICATIONS

Periodical reports on the projects being carried out were combined and issued as monthly reports of the station for interoffice circulation within the Department. The subject matter of 84 individual project reports comprised a total of 295 mimeographed pages issued during the year. Copies were sent on request to 45 individuals and institutions interested professionally in the activities of the station.

The following manuscripts prepared by station workers from the results of their investigations were published through facilities offered by the Department:

Bailey, Wallace K. Experiments in Controlling Corn Ear Pests in Puerto Rico. Puerto Rico Agr. Expt. Sta. (Mayaguez) Cir. 23, 23 pp., illus. 1940.

Horn, Claud L. Stimulation of Growth in Juvenile Mangosteen Plants. Jour. Agr. Res. 61: 397–400, illus. 1940.

Seven additional papers based on work done at the station were published outside the Department during the year. These are given in the following bibliographical list:

Bailey, Wallace K., and Plank, H. K. An agromyzid fly infesting sweetpotato seed in Puerto Rico. Jour. Econ. Ent. 33: 704–705. 1940.

Balls, A. K., and Arana, Francisca E. Determination and significance of phenols in vanilla extract. Assoc. Off. Agr. Chem. Jour. 24: 507–512, illus. 1941.

Bartlett, Kenneth A. The introduction and colonization in Puerto Rico of beneficial insects parasitic on West Indian fruitflies. Puerto Rico Univ. Jour. Agr. 25: 25–31. 1941.

Horn, Claud L. Existence of only one variety of cultivated mangosteen explained by asexually formed "seed." Science 92: 237–238. 1940.

Horn, Claud L. Biological science helps to develop a new relief for human suffering. N. Y. Bot. Gard. Jour. 42 (Sect. 1): 88–92, illus. 1941.

Pennock, William. [Pineapple cultivation in Puerto Rico.] *In* La Piña por John Wesley Coulter. Unión Panamer. Pub. Agr. Nos. 134–136, pp. 35–53, illus. 1940.

Kevorkian, Arthur G., and Horn, Claud L. The use of fungicides on orchids. Amer. Orchid Soc. Bul. 9: 328–330, illus. 1941.

The English edition of the annual report of the station for 1939, containing 126 pages and 43 illustrations, was issued in October. This report was translated into Spanish and submitted for publication during the latter part of the year. Similar translations of the reports for 1937 and 1938 were issued in November and March, respectively.

Increasing requests for the Spanish edition indicate a growing interest in the results of the work of the station, not only among local farmers but also in neighboring countries of the Western Hemisphere. During the year this edition was sent to 81 institutions and individuals in 13 of these countries.

U. S. GOVERNMENT PRINTING OFFICE: 1942